PCT/JP2004/008936

05. 8. 2004

Patent Office
Canberra

REC'D 26 AUG 2004
WIPO PCT

I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003903075 for a patent by NEC AUSTRALIA PTY LTD as filed on 18 June 2003.

WITNESS my hand this
Thirteenth day of July 2004

J. Billingsley

JULIE BILLINGSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH
RULE 17.1(a) OR (b)

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: **Cell search process for wireless communication system**

The invention is described in the following statement:

CELL SEARCH PROCESS FOR WIRELESS COMMUNICATION SYSTEM

The present invention relates generally to wireless communication systems having a plurality of base stations and a mobile station, and in particular to the cell search process performed by the mobile station. The present invention is suitable for use in spread spectrum systems, and in particular in wide band code division multiple access (W-CDMA) systems, and it will be convenient to describe the invention in relation to that exemplary, non-limiting application.

In W-CDMA and like wireless communication systems, a mobile station can receive a number of radio signals transmitted from several base stations - each serving a separate cell within a service area - via multiple propagation paths. A cell search process is carried out by the mobile station to synchronise the mobile station with a base station of a cell prior to transmission of traffic data, such as voice data.

The standard cell search process involves three steps, namely slot synchronisation, code-group identification and frame synchronisation, and long scrambling code identification. During slot synchronisation, the mobile station uses a primary synchronisation code continuously transmitted in a primary synchronisation channel to acquire slot synchronisation to a cell. During the second step of the cell search procedure, the mobile station uses the synchronisation channel's secondary synchronisation code to find frame synchronisation and identify the code group of the cell found in the slot synchronisation step. During the third step of the cell search procedure, the mobile station determines the exact primary scrambling code used by the found cell.

In a W-CDMA mobile station, it is sometimes necessary to perform a cell search of all supported radio channels to try to find downlink signals from all visible cells. W-CDMA radio channels are specified on a grid with a resolution, or channel raster, of 200 kHz (in the case of the UMTS Standard). The standard cell search process carried out by existing mobile stations is to progress through each possible radio channel and perform a full cell search process on each one. The cell search process therefore takes a significant time and the resulting full band scan

may take several minutes. Moreover, the standard cell search process requires significant processing power and time, which occupies resources that may be required for other processing functions and consumes power in the mobile station.

It would therefore be desirable to provide a cell search process that ameliorates or overcomes one or more disadvantages of known cell search processes carried out by mobile stations in wireless communication systems.

It would also be desirable to provide a cell search process that is rapid, and minimising the processing power and energy requirements of a mobile station.

One aspect of the invention provides a method of cell search in a wireless communication systems having a plurality of base stations and a mobile station, each of the plurality of base stations serving a separate cell within a service area and transmitting a common primary synchronisation code (PSC) in a primary synchronisation channel within a slot of a radio frame, the method including the steps of:

(a) scanning through radio channels in scanning increments corresponding to a standard channel raster;

(b) estimating the PSC signal-to-noise ratio of each radio channel;

(c) if a PSC signal-to-noise ratio is above a first predetermined threshold level, completing a cell search procedure including slot synchronisation, frame synchronisation and scrambling code detection steps for that radio channel;

(d) if the cell search procedure is successfully completed for the radio channel in step (c), increasing the scanning increments to the broadcast frequency separation between cells;

(e) when all radio channels are scanned in step (d), sorting the scanned radio channels in descending order by PSC signal-to-noise ratio; and

(f) performing the cell search procedure on each sorted radio channel in descending order.

Using this method, a cell is typically identified within the first few channels. The resulting time for a full band scan is normally only a few seconds, compared to the several minutes required to carry out the current cell search process.

Preferably, if the cell search procedure defined by steps (a) to (f) is not successful, the method includes the step of:

if more than a predetermined number of sorted radio channels have been searched without detecting cells on any of the searched radio channels, discontinuing the cell search procedure.

Another aspect of the invention provides a mobile station for use in a wireless communication system including a plurality of base stations, each of the plurality of base stations serving a separate cell within a service area and transmitting a common primary synchronisation code (PSC) in a primary synchronisation channel within a slot of a radio frame, the mobile station including:

scanning means for scanning through possible radio channels;

cell search means for completing a cell search procedure including slot synchronisation means, frame synchronisation means and scrambling code detection means; and

processing means for controlling operation of the mobile station, wherein the scanning means scans through possible radio channels in scanning increments corresponding to a standard channel raster;

the slot synchronisation means estimates the PSC signal-to-noise ratio of each radio channel;

the cell search acts to complete the cell search procedure for that radio channel, if the processing means determines that the PSC signal-to-noise ratio is above a first predetermined threshold level;

the processing means increasing the scanning increments to the broadcast frequency separation between cells, if the cell search procedure is successfully completed for that radio channel;

the processing means further acting to sort the scanned radio channels in descending order by PSC signal-to-noise ratio when all radio channels are scanned;

the cell search means performing the cell search procedure on each sorted radio channel in descending order.

The following description refers in more detail to the various features of the

present invention. To facilitate an understanding of the invention, reference is made in the description to the accompanying drawings where the cell search method and mobile station for carrying out the cell search method are illustrated in a preferred embodiment. It is to be understood however that the invention is not limited to the preferred embodiment illustrated in the drawings.

In the drawings:

Figure 1 is a schematic diagram illustrating a W-CDMA wireless communication systems;

Figure 2 is a schematic diagram of functional elements of a mobile station forming part of the wireless communication systems of Figure 1;

Figure 3 is a flow chart illustrating the broad functional steps performed by the mobile station of Figure 2 when carrying out a cell search in accordance with one embodiment of the present invention; and,

Figures 4 and 5 are flow charts showing in more detail the various functional steps carried out by the mobile station of Figure 2 in performing two of the steps shown in the flow chart of Figure 3.

Referring now to Figure 1, there is shown generally a wireless communication system 10 including a W-CDMA network 12 and base stations 14, 16 and 18. A mobile station 20 can receive a number of radio signals transmitted from cells served by the base stations 14 to 18 via multiple propagation paths. When the mobile station 20 performs a cell search, it receives a plurality of multi-path radio signals originating from the base stations 14 to 18, which are shifted in timing from each other due to signal reflection and diffraction.

Figure 2 is a schematic diagram showing a schematic structure of the mobile station 20. This mobile station 29 includes an antenna 32, a demodulator for down converting the radio signals received by the antenna 32 to a base band frequency, and analogue to digital converter 36 which converts received analogue signals into digital signals, a slot timing detector 38 for detecting slot timing during cell search, a frame timing and code-group detector 42 which detects frame timing and code-group during cell search, a scrambling-code detector 44 which detects a scrambling-

code during cell search, a demodulator 46 which demodulates a received code with detected spread codes, a decoder 9 which decodes the received signals demodulated by the demodulator 46, a microprocessor 40 which controls operation of the mobile station 20 and a memory 50 for storing a program to be executed by the microprocessor 40 as well as data required by the microprocessor 40 in the performance of its various operations. The slot timing detector 38 additionally includes a filter 52 matched to the primary synchronisation code transmitted in a primary synchronisation channel by the base stations 14 to 18, and a signal-to-noise estimator 54.

The operation of the mobile station 20 in the performance of a cell search according to one embodiment of the present invention will now be described with reference to Figures 3 to 5. At step 72, the first phase of the W-CDMA band scan is conducted. In this phase, a scan is performed through all possible radio channels, estimating and storing the primary synchronisation channel signal-to-noise ratio. The scanning increment corresponds to the standard W-CDMA system channel raster. In the case of the UMTS Standard, this channel raster is 200 kHz.

If the signal-to-noise ratio is above a first predetermined threshold value, a standard cell search process is performed. The first predetermined threshold value is selected so that a signal has a high likelihood of belonging to an actual cell, rather than being a random noise peak. If the cell search process is successful, namely the mobile station is able to synchronisation with a cell broadcast channel, the scanning increment is modified to a value corresponding to the frequency separation between cells. For the UMTS Standard, the frequency separation between cells is 5 MHz. Information about the located cell is stored within the mobile station.

At step 74, after scanning through all radio channels in this manner, the radio channels are then sorted in descending order, by the primary synchronisation channel signal-to-noise ratio.

At step 76, the second phase of the W-CDMA band scan is carried out. Accordingly, the mobile terminal then starts to progress through the sorted radio channels. Each next channel is selected from the sorted list in such a way that there

is at least 5 MHz apart from channels on which any cells have already been identified. Once a channel is selected, a full cell search process is performed on this channel. If the cell search is successful, information about the found cell is stored in the memory of the mobile station. The mobile station then progresses to the next channel in the sorted list and a full cell search process again performed on that channel.

A more detailed understanding of the cell search process illustrated in Figure 3 is shown in Figures 4 and 5. In Figure 4, at step 92, the microprocessor 40 acts to demodulate the received radio signals to a first possible radio channel within the band to be scanned. The microprocessor 40 acts to adjust the demodulator 34 by 200kHz each time a cell search process is undertaken for a new W-CDMA radio channel. At step 94, a next W-CDMA radio channel is selected.

At step 96, the first step of the cell search procedure is carried out by the mobile station, namely slot synchronisation. In this step, the mobile station uses the synchronisation channel's primary synchronisation code to acquire slot synchronisation to a cell. After the received signal is demodulated to a base band signal by the demodulator 34, and converted into a digital representation of that signal by the A/D converter 36, the digitised signal is processed by the matched filter 52. The matched filter 52 is matched to the primary synchronisation code transmitted by all base stations in a primary synchronisation channel within a slot of a radio frame. The output of the matched filter 52 is a series of pulses which represent the magnitudes of the received primary synchronisation code power for those cells detected by the matched filter 52. The signal-to-noise estimator 54 is coupled to the matched filter 52 and estimates the primary synchronisation code signal-to-noise ratio of the radio channel for which cell search process is currently being conducted.

At step 98, the primary synchronisation channel signal-to-noise ratio is derived and proved to the microprocessor 40. At step 100, a determination is made by the microprocessor 40 as to whether the signal-to-noise ratio is above a first predetermined threshold level indicative that the radio signal has a high likelihood

of belonging to an actual cell. If the first predetermined threshold level is not exceeded, then the PSC signal-to-noise ratio for this radio channel is stored by the microprocessor 40 in the memory 50.

Alternatively, if the first predetermined threshold level is exceeded at step 100, the second step of the W-CDMA cell search is carried out, namely frame synchronisation. During this step, the mobile station uses the search channel's secondary synchronisation code to find frame synchronisation and identify the code group of the cell found in the slot synchronisation step. This is done by correlating the received signal with all possible secondary synchronisation code sequences, and identifying a maximum correlation value. Since the cyclic shifts of the sequences are unique, the code-group as well as the frame synchronisation is determined by the frame timing and code-group detector 42.

At step 104, step 3 of the W-CDMA cell search process is carried out, namely scrambling-code detection. In this third step, the mobile station determines the exact primary scrambling code used by the found cell. The primary scrambling code is typically identified through symbol-by-symbol correlation over the CPICH with all codes within the code group identified in the second frame synchronisation and code-group identification step.

At step 106, a common pilot channel sliding correlation is performed. If the correlation peak is determined at step 108 as being less than a second predetermined threshold level, then the cell search process for that radio channel is stopped, and the PSC signal-to-noise ratio for that radio channel is stored in the memory 50. However, if the correlation peak is above the second predetermined threshold level, a broadcast channel synchronisation step is performed at step 110. If it is determined at step 112 that broadcast channel synchronisation was not successful, then once again the cell search process for that radio channel is stopped and the PSC signal-to-noise ratio is stored in the memory 50 at step 120. However, if the broadcast channel synchronisation was successful, then at step 114 the cell is determined to have been detected by the cell search process and information about the found cell is stored in the cell list maintained in the memory 50 of the mobile

station.

At step 116, the scanning increments for the cell search process are increased to the broadcast frequency separation between cells. For the UMTS Standard, this is 5 MHz. If at step 118 it is found that all W-CDMA radio channels have yet to be scanned, the next W-CDMA radio channel for which the cell search process is to be conducted is selected and steps 94 to 120 repeated. It will be appreciated that if the mobile station does not synchronise the radio channel in question, the next W-CDMA radio channel selected will be incremented by 200 kHz, whereas if the mobile station has synchronised the cell broadcast channel, then the next W-CDMA radio channel will be incremented by 5 MHz from the previous radio channel.

Having now scanned through all radio channels in the manner illustrated in Figure 4, the radio channels are then sorted in descending order by the microprocessor 40 by the PSC signal-to-noise ratio at step 74.

As seen in Figure 5, the mobile terminal then progresses its way through the sorted radio channels, conducting a full cell search process on each. At step 124, the next channel to be search by the mobile station is selected. At steps 126, 128 and 130 the slot synchronisation, frame synchronisation and scrambling-code detection steps of the W-CDMA cell serch are conducted in the manner preciously described. In steps 132 and 134, the common pilot channel sliding correlation and broadcast channel synchronisation steps previously described are then carried out.

If it is determined at step 136 that the broadcast channel synchronisation steps was successful, then at step 138 the radio signal currently being searched is determined to belong to an actual cell, and cell data is stored in the cell list maintained in the memory 50 of the mobile station. Alternatively, if the broadcast channel synchronisation was not successful, then at step 140 the microprocessor 40 determines whether any cells have yet been identified in the cell search procedure according to the present invention.

If one or more cells have been identified in this manner, or if the broadcast channel synchronisation was successful, then another determination is made at step 142 as to whether all radio channels in the set of radio channels sorted according to

PSC signal-to-noise ratio have been scanned. If this is not the case, then the next channel is selected from the sorted list at step 124, that radio channel being selected in a way which is at least 5 MHz away from any channels on which cells have already been identified. The cell search process for that next channel is then carried out. Once all sorted channels have been scanned, the W-CDMA band scan is completed at step 144.

However, if the broadcast channel synchronisation was not successful, as determined by step 136 and if no cells had yet been identified within this procedure, as determined by step 140, then a determination is made by the microprocessor 40 at step 146 as to whether the first 10% of channels in the sorted set have already been scanned. If this is not the case, then the next and subsequent channels from the sorted set are scanned to determine whether any cells are detected. If, however, the first 10% of the channels in the sorted set have already been scanned, then the W-CDMA band scan is determined at step 148 to have failed.

Accordingly, if the cell search is not successful, the mobile station checks whether it has identified any cell so far. If not and it has already progressed through 10% of the sorted channel set, the procedure is terminated, as there is now a very low likelihood that there are any detectable cells on any of the system's radio channels.

It is to be understood that modifications or additions may be made to the above described preferred embodiment of the invention without departing from the spirit or ambit of the present invention.

DATED this 17 June 2003

FREEHILLS CARTER SMITH BEADLE

Patent Attorneys for the Applicant

NEC AUSTRALIA PTY LTD

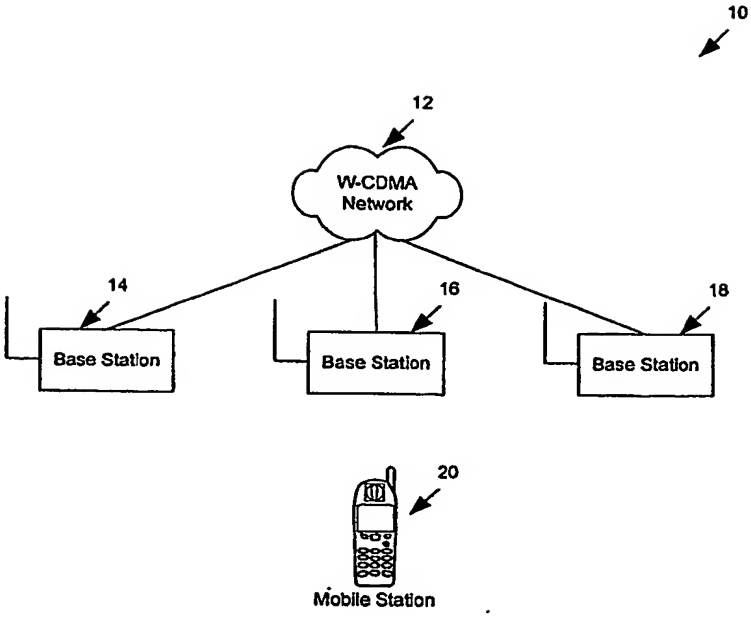

Figure 1

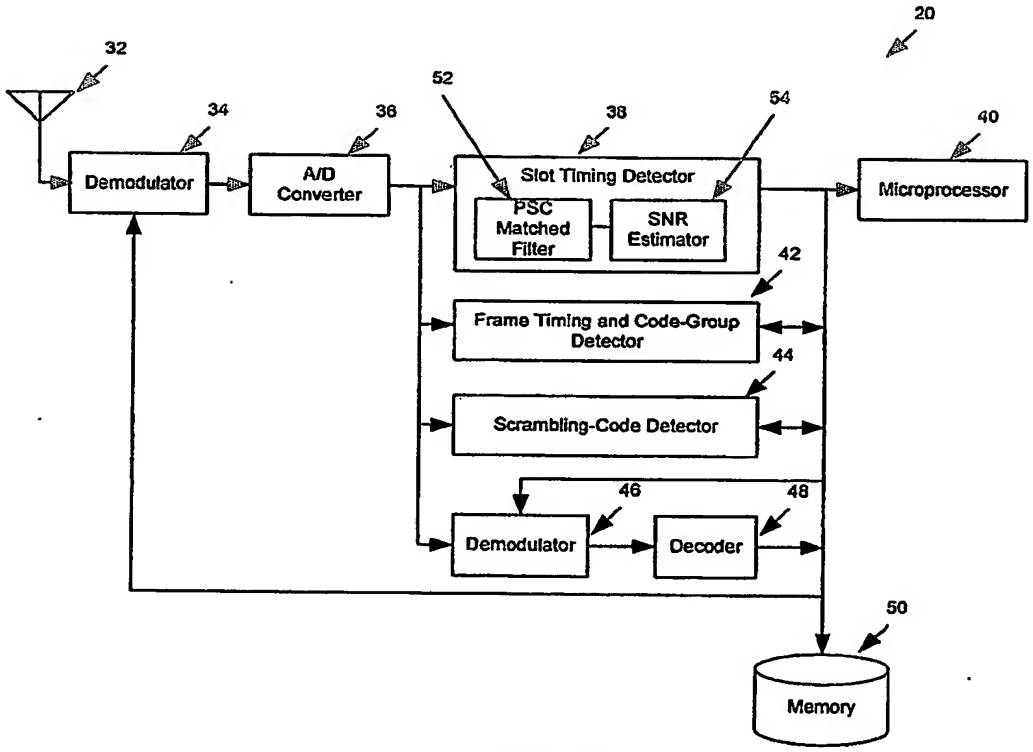

Figure 2

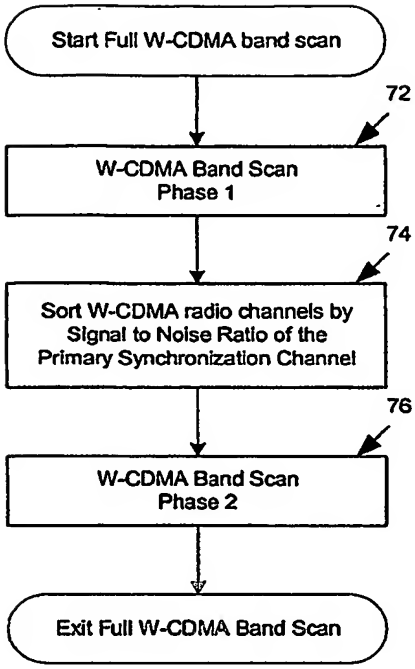
Start Full W-CDMA band scan
72
W-CDMA Band Scan
Phase 1
74
Sort W-CDMA radio channels by
Signal to Noise Ratio of the
Primary Synchronization Channel
76
W-CDMA Band Scan
Phase 2
Exit Full W-CDMA Band Scan

Figure 3

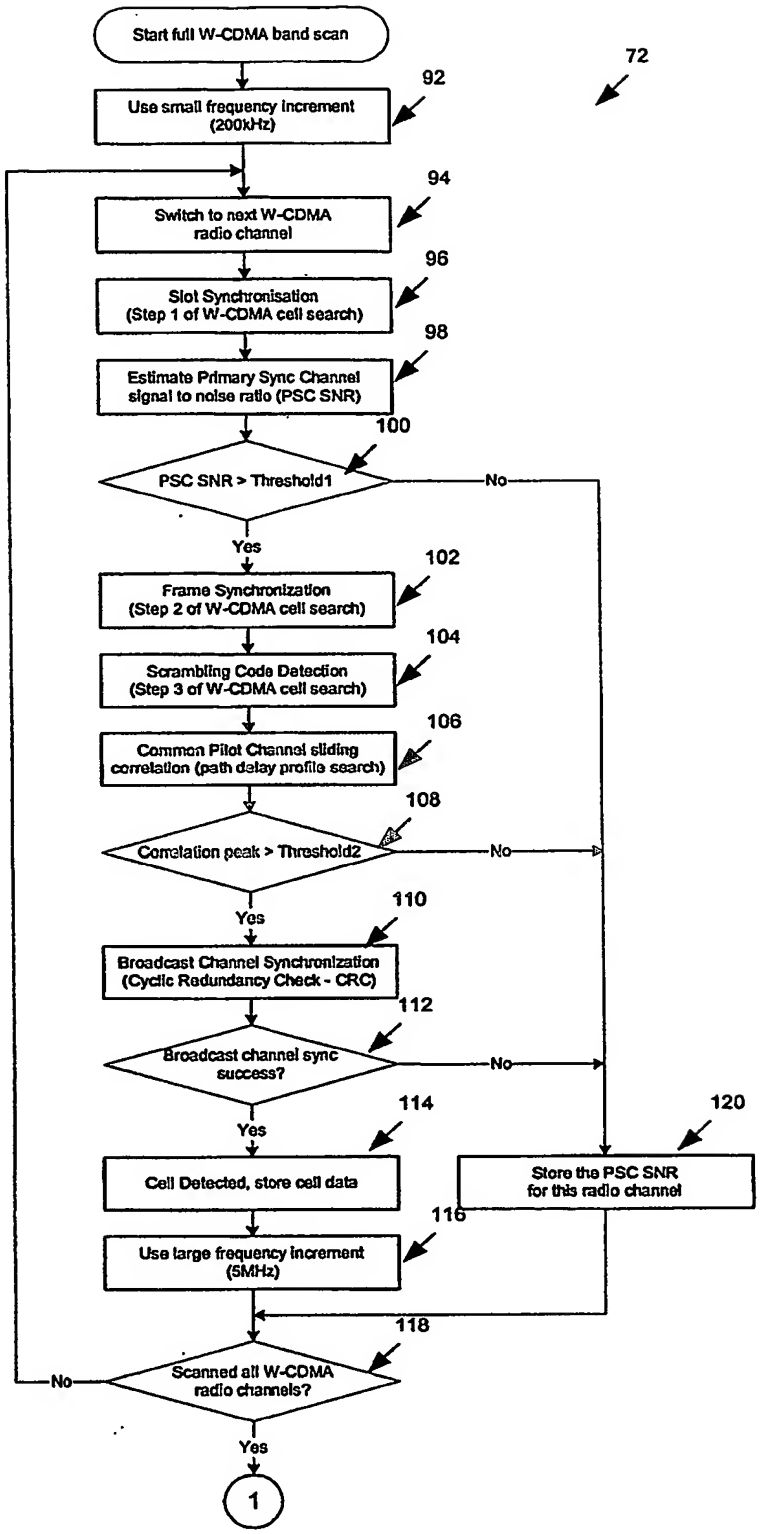
Start full W-CDMA band scan
72
92
Use small frequency increment (200kHz)
94
Switch to next W-CDMA radio channel
96
Slot Synchronisation (Step 1 of W-CDMA cell search)
98
Estimate Primary Sync Channel signal to noise ratio (PSC SNR)
100
PSC SNR > Threshold1
No
Yes
102
Frame Synchronization (Step 2 of W-CDMA cell search)
104
Scrambling Code Detection (Step 3 of W-CDMA cell search)
106
Common Pilot Channel sliding correlation (path delay profile search)
108
Correlation peak > Threshold2
No
Yes
110
Broadcast Channel Synchronization (Cyclic Redundancy Check - CRC)
112
Broadcast channel sync success?
No
Yes
114
Cell Detected, store cell data
120
Store the PSC SNR for this radio channel
116
Use large frequency increment (5MHz)
118
Scanned all W-CDMA radio channels?
No
Yes
1

Figure 4

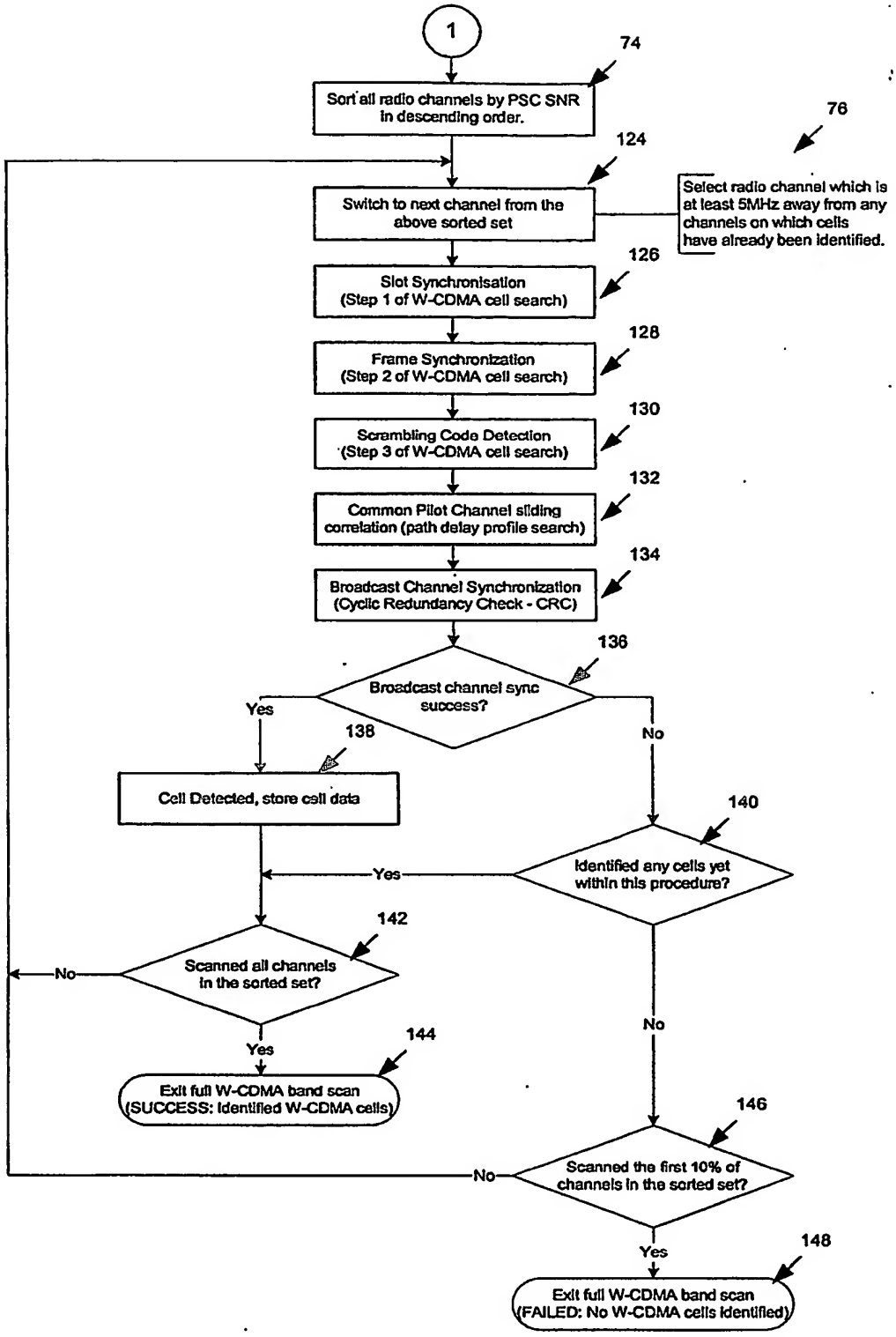
1
74
Sort all radio channels by PSC SNR in descending order.
76
124
Switch to next channel from the above sorted set
Select radio channel which is at least 5MHz away from any channels on which cells have already been identified.
126
Slot Synchronisation (Step 1 of W-CDMA cell search)
128
Frame Synchronization (Step 2 of W-CDMA cell search)
130
Scrambling Code Detection (Step 3 of W-CDMA cell search)
132
Common Pilot Channel sliding correlation (path delay profile search)
134
Broadcast Channel Synchronization (Cyclic Redundancy Check - CRC)
136
Broadcast channel sync success?
Yes
No
138
Cell Detected, store cell data
140
Identified any cells yet within this procedure?
Yes
142
Scanned all channels in the sorted set?
No
Yes
144
Exit full W-CDMA band scan (SUCCESS: Identified W-CDMA cells)
No
146
Scanned the first 10% of channels in the sorted set?
No
Yes
148
Exit full W-CDMA band scan (FAILED: No W-CDMA cells identified)

Figure 5